(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
18 January 2001 (18.01.2001)

PCT

(10) International Publication Number
WO 01/04535 A1

(51) International Patent Classification[7]: F16L 55/16

(21) International Application Number: PCT/US00/18635

(22) International Filing Date: 7 July 2000 (07.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/143,039 9 July 1999 (09.07.1999) US
60/146,203 29 July 1999 (29.07.1999) US

(71) Applicant *(for all designated States except US)*: **ENVENTURE GLOBAL TECHNOLOGY** [US/US]; 2135 Highway 6 South, Houston, TX 77077 (US).

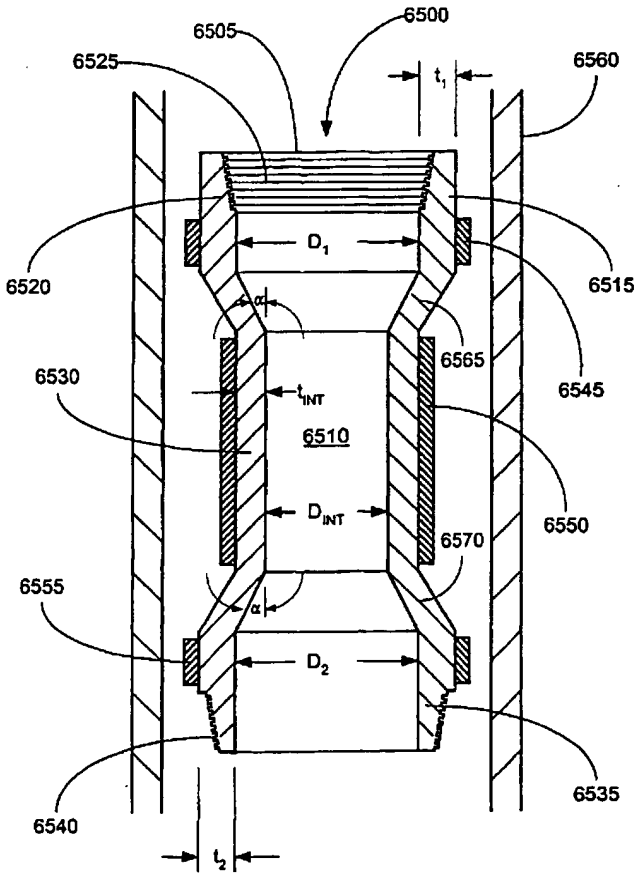
(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **COOK, Robert, Lance** [US/US]; 934 Caswell Court, Katy, TX 77450 (US). **BRISCO, David, P.** [US/US]; 405 Westridge Drive, Duncan, OK 73533 (US). **STEWART, R., Bruce** [GB/NL]; Wassenaarseweg 208, NL-2596 EC The Hague (NL). **WYANT, Reece, E.** [US/US]; -- (**). **RING, Lev** [US/US]; 14126 Heatherhill Place, Houston, TX 77077 (US). **NAHM, James, Jang, Woo** [—/US]; -- (**). **HAUT, Richard, Carl** [US/US]; 502 Lakebend Drive, Sugar Land, TX 77479-5831 (US). **MACK, Robert, Donald** [US/US]; 22435 Vobe Court, Katy, TX 77449 (US). **DUELL, Alan, B.** [US/US]; 1408 Wisteria, Duncan, OK 73533 (US). **FILIPPOV, Andrei, Gregory** [US/US]; 2606 Hidden Shore Drive, Katy, TX 77450 (US).

(74) Agents: **MATTINGLY, Todd** et al.; Haynes and Boone, L.L.P., Suite 4300, 1000 Louisiana Street, Houston, TX 77002-5012 (US).

[Continued on next page]

(54) Title: TWO-STEP RADIAL EXPANSION



(57) Abstract: A two-step radial expansion process. A first tubular member (6530) is radially expanded into contact with the interior surface of a second tubular member (6550). Both tubular members are then radially expanded.

WO 01/04535 A1

(81) **Designated States** *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) **Designated States** *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:

— *With international search report.*

— *With amended claims.*

Date of publication of the amended claims: 19 April 2001

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

AMENDED CLAIMS
[received by the International Bureau on 18 December 2000 (18.12.00);
new claims 8-63 added; remaining claims unchanged (12 pages)]

1. An expandable tubular member, including:
a first tubular section having a first outer diameter;
an intermediate tubular section coupled to the first tubular section having an intermediate outer diameter; and
a second tubular section having a second outer diameter coupled to the intermediate tubular section having a second outer diameter;
wherein the first and second outer diameters are greater than the intermediate outer diameter.

2. A method of fabricating an expandable tubular member, comprising:
providing a tubular member having a first end, a second end, and an intermediate portion; and
radially expanding the first end and the second end of the tubular member.

3. An apparatus, comprising:
a tubular member formed by the process of radially expanding an unexpanded tubular member into contact with an approximately cylindrical passage using an expansion cone, the unexpanded tubular member including:
a first tubular section having a first outer diameter;
an intermediate tubular section coupled to the first tubular section having an intermediate outer diameter; and
a second tubular section having a second outer diameter coupled to the intermediate tubular section having a second outer diameter;
wherein the first and second outer diameters are greater than the intermediate outer diameter.

4. A method of joining a first tubular member to a second tubular member, comprising:

positioning at least a portion of the second tubular member within the first tubular member;

radially expanding at least a portion of the second tubular member into contact with the first tubular member; and

radially expanding the first and second tubular members;

wherein the interior diameter of the radially expanded second tubular member is substantially equal to the interior diameter of the radially unexpanded portion of the first tubular member.

5. A tubular member, comprising:

a first tubular member; and

a second tubular member coupled to the first tubular member;

wherein the first and second tubular members are coupled by the process of:

positioning at least a portion of the second tubular member within the first tubular member;

radially expanding at least a portion of the second tubular member into contact with the first tubular member; and

radially expanding the first and second tubular members;

wherein the interior diameter of the radially expanded second tubular member is substantially equal to an interior diameter of the radially unexpanded portion of the first tubular member.

6. A tubular member, comprising:

a first tubular member, including:

an upper portion having an upper wall thickness; and

a lower portion having a lower wall thickness; and

a second tubular member coupled to the lower portion of the first tubular member;

wherein the interior diameters of the upper portion of the first tubular member and the second tubular member are substantially equal.

7. An apparatus, comprising:

a first tubular member;

a second tubular member positioned in overlapping relation to the first tubular member;

an expansion mandrel positioned within the first tubular member including one or more outer surfaces for radially expanding the first and second tubular members;

a support member coupled to the expansion mandrel for supporting the expansion mandrel;

a first fluid conduit positioned within the expansion mandrel and the support member;

a packer sealingly coupled to the first tubular member and slidingly and sealingly coupled to the support member;

a second fluid conduit coupled to the packer; and

a pump fluidicly coupled to the second fluid conduit.

8. An expansion cone for expanding a tubular member, comprising:
a housing including a tapered first end and a second end;
one or more grooves formed in the outer surface of the tapered first end; and
one or more axial flow passages fluidicly coupled to the circumferential grooves.

9. The expansion cone of claim 8, wherein the grooves comprise circumferential grooves.

10. The expansion cone of claim 8, wherein the grooves comprise spiral grooves.

11. The expansion cone of claim 8, wherein the grooves are concentrated around the axial midpoint of the tapered portion of the housing.

12. The expansion cone of claim 8, wherein the axial flow passages comprise axial grooves.

13. The expansion cone of claim 12, wherein the axial grooves are spaced apart by at least about 3 inches in the circumferential direction.

14. The expansion cone of claim 12, wherein the axial grooves extend from the tapered first end of the body to the grooves.

15. The expansion cone of claim 12, wherein the axial grooves extend from the second end of the body to the grooves.

16. The expansion cone of claim 12, wherein the axial grooves extend from the tapered first end of the body to the second end of the body.

17. The expansion cone of claim 8, wherein the flow passages are positioned within the housing of the expansion cone.

18. The expansion cone of claim 17, wherein the flow passages extend from the tapered first end of the body to the grooves.

19. The expansion cone of claim 17, wherein the flow passages extend from the tapered first end of the body to the second end of the body.

20. The expansion cone of claim 19, wherein the flow passages extend from the second end of the body to the grooves.

21. The expansion cone of claim 19, wherein one or more of the flow passages include inserts having restricted flow passages.

22. The expansion cone of claim 19, wherein one or more of the flow passages include filters.

23. The expansion cone of claim 8, wherein the cross sectional area of the grooves is greater than the cross sectional area of the axial flow passages.

24. The expansion cone of claim 8, wherein the cross-sectional area of the grooves ranges from about $2X10^{-4}$ in^2 to $5X10^{-2}$ in^2.

25. The expansion cone of claim 8, wherein the cross-sectional area of the axial flow passages ranges from about $2X10^{-4}$ in^2 to $5X10^{-2}$ in^2.

26. The expansion cone of claim 8, wherein the angle of attack of the first tapered end of the body ranges from about 10 to 30 degrees.

27. The expansion cone of claim 8, wherein the grooves are concentrated in a trailing edge portion of the tapered first end.

28. The expansion cone of claim 8, wherein the angle of inclination of the axial flow passages relative to the longitudinal axis of the expansion cone is greater than the angle of attack of the first tapered end.

29. The expansion cone of claim 8, wherein the grooves include:

a flow channel having a first radius of curvature;

a first shoulder positioned on one side of the flow channel having a second radius of curvature; and

a second shoulder positioned on the other side of the flow channel having a third radius of curvature.

30. The expansion cone of claim 29, wherein the first, second and third radii of curvature are substantially equal.

31. The expansion cone of claim 8, wherein the axial flow passages include:

a flow channel having a first radius of curvature;

a first shoulder positioned on one side of the flow channel having a second radius of curvature; and

a second shoulder positioned on the other side of the flow channel having a third radius of curvature.

32. The expansion cone of claim 31, wherein the first, second and third radii of curvature are substantially equal.

33. The expansion cone of claim 31, wherein the second radius of curvature is greater than the third radius of curvature.

34. A method of lubricating the interface between a tubular member and an expansion cone having a first tapered end and a second end during the radial expansion of the tubular member by the expansion cone, wherein the interface between the tubular member and the first tapered end of the expansion cone includes a leading edge portion and a trailing edge portion, comprising:

injecting a lubricating fluid into the trailing edge portion.

35. The method of claim 34, wherein the lubricating fluid has a viscosity ranging from about 1 to 10,000 centipoise.

36. The method of claim 34, wherein the injecting includes:

injecting lubricating fluid into the first tapered end of the expansion cone.

37. The method of claim 36, wherein the injecting includes:

injecting lubricating fluid into the area around the axial midpoint of the first tapered end of the expansion cone.

38. The method of claim 34, wherein the injecting includes:

injecting lubricating fluid into the second end of the expansion cone.

39. The method of claim 34, wherein the injecting includes:

injecting lubricating fluid into the tapered first end and the second end of the expansion cone.

40. The method of claim 34, wherein the injecting includes:

injecting lubricating fluid into the interior of the expansion cone.

41. The method of claim 34, wherein the injecting includes:

injecting lubricating fluid through the outer surface of the expansion cone.

42. The method of claim 34, wherein the injecting includes:
injecting the lubricating fluid into a plurality of discrete locations along the trailing edge portion.

43. The method of claim 34, wherein the lubricating fluid comprises:
drilling mud.

44. The method of claim 42, wherein the lubricating fluid further includes:
TorqTrim III;
EP Mudlib; and
DrillN-Slid.

45. The method of claim 34, wherein the lubricating fluid comprises:
TorqTrim III;
EP Mudlib; and
DrillN-Slid.

46. A method of removing debris formed during the radial expansion of a tubular member by an expansion cone from the interface between the tubular member and the expansion cone, the expansion cone including a first tapered end and a second end, the interface between the tubular member and the first tapered end of the expansion cone includes a leading edge portion and a trailing edge portion, comprising:
injecting a lubricating fluid into the interface between the tubular member and the expansion cone.

47. The method of claim 46, wherein the lubricating fluid has a viscosity ranging from about 1 to 10,000 centipoise.

48. The method of claim 46, wherein the injecting includes:
injecting lubricating fluid into the first tapered end of the expansion cone.

49. The method of claim 48, wherein the injecting includes:
injecting lubricating fluid into the area around the axial midpoint of the first tapered end of the expansion cone.

50. The method of claim 46, wherein the injecting includes:
injecting lubricating fluid into the second end of the expansion cone.

51. The method of claim 46, wherein the injecting includes:
injecting lubricating fluid into the tapered first end and the second end of the expansion cone.

52. The method of claim 46, wherein the injecting includes:
injecting lubricating fluid into the interior of the expansion cone.

53. The method of claim 46, wherein the injecting includes:
injecting lubricating fluid through the outer surface of the expansion cone.

54. The method of claim 46, wherein the lubricating fluid comprises:
drilling mud.

55. The method of claim 54, wherein the lubricating fluid further includes:
TorqTrim III;
EP Mudlib; and
DrillN-Slid.

56. The method of claim 46, wherein the lubricating fluid comprises:
TorqTrim III;
EP Mudlib; and
DrillN-Slid.

57. A tubular member, comprising:
an annular member, including:
a wall thickness that varies less than about 8 %;
a hoop yield strength that varies less than about 10 %;
imperfections of less than about 8 % of the wall thickness;
no failure for radial expansions of up to about 30 %; and
no necking of the walls of the annular member for radial expansions of up to about 25%.

58. A wellbore casing, comprising:
one or more tubular members, each tubular member including:
an annular member, including:
a wall thickness that varies less than about 8 %;
a hoop yield strength that varies less than about 10 %;
imperfections of less than about 8 % of the wall thickness;
no failure for radial expansions of up to about 30 %; and
no necking of the walls of the annular member for radial expansions of up to about 25%.

59. A method of forming a wellbore casing, comprising:

placing a tubular member and an expansion cone in a wellbore; and

displacing the expansion cone relative to the tubular member;

wherein the tubular member includes:

an annular member, including:

a wall thickness that varies less than about 8 %;

a hoop yield strength that varies less than about 10 %;

imperfections of less than about 8 % of the wall thickness;

no failure for radial expansions of up to about 30 %; and

no necking of the walls of the annular member for radial expansions of up to about 25%.

60. A method of selecting a group of tubular members for subsequent radial expansion, comprising:

radially expanding the ends of a representative sample of the group of tubular members;

measuring the amount of necking of the walls of the radially expanded ends of the tubular members; and

if the radially expanded ends of the tubular members do not exhibit necking for radial expansions of up to about 25%, then accepting the group of tubular members.

61. A method of selecting a group of tubular members, comprising:

radially expanding the ends of a representative sample of the group of tubular members until each of the tubular members fail;

if the radially expanded ends of the tubular members do not fail for radial expansions of up to about 30%, then accepting the group of tubular members.

62. A method of inserting a tubular member into a wellbore, comprising:
injecting a lubricating fluid into the wellbore; and
inserting the tubular member into the wellbore.

63. The method of claim 32, wherein the lubricating fluid comprises:
BARO-LUB GOLD-SEAL™ brand drilling mud lubricant.